

DOCUMENT RESUME

ED 043 473

RE 003 178

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TITLE An Analysis of Three Theories of the Relationships
Among Reading Comprehension Skills.
PUB DATE 2 May 69
NOTE 17p.; Paper presented at the meeting of the
International Reading Association, Kansas City, Mo.,
Apr. 30-May 3, 1969

EDRS PRICE EDRS Price MF-\$0.25 HC-\$0.95
DESCRIPTORS *Educational Theories, Factor Analysis, *Models,
*Reading Comprehension, *Reading Research, *Reading
Skills, Sequential Learning

ABSTRACT

The focus in this analysis is on three theories of the relationships among reading comprehension skills primarily relating to the skills used in reading, not to the process or to the instructional procedures used for reading, as differentiated by Robinson. Consideration is given to three factors: (1) the existing need for theories and models in the systematic study of the relationships among the comprehension skills, (2) the definitive purposes served by models and theories, and (3) a discussion of three theories reviewed from theoretical and empirical research utilizing models based on these theories which explain how the component skills of reading comprehension are related to each other. The three theories are defined as follows: (1) The independent or isolated skills theory implies that reading comprehension is a set of different processes which may be learned independently from each other and in any sequence. (2) The global theory asserts that reading comprehension is a single or unitary general process, which after being learned will enable the learner to answer any kind of comprehension question about a given passage. (3) The hierarchical skills theory asserts that reading skills can be arranged into levels according to the complexity of the behavior necessary to learn each skill. Implications are also made to contemporary educational practice. Tables and references are included. (Author/DH)

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An Analysis of Three Theories of the
Relationships Among Reading Comprehension Skills

SYMPOSIUM II -
Applications of Psycholinguistics to Key Problems in Reading

Carita A. Chapman

INTRODUCTION

This analysis will focus on three theories of the relationships among reading comprehension skills primarily relating to the skills used in reading, not to the process nor to the instructional procedures used for reading, as differentiated by Robinson (20). This analysis will give consideration to three factors: first, to the existing need for theories and models in the systematic

study of the relationships among the comprehension skills; second, to the definitive purposes served by models and theories; and, third, to a discussion of the three theories reviewed from theoretical and empirical research utilizing models based on these theories, which explain how the component skills of reading comprehension are related to each other. Implications will also be made to contemporary educational practice.

NEED FOR THEORIES AND MODELS

The recent national survey conducted by Austin and Morrison (1) found that school systems "reported a 'considerable' amount of time was devoted to developing [comprehension]...[however, there were]... persistent criticisms of and undeniable dissatisfaction with, the extent to which schools develop comprehension." This situation was not new, for Thorndike (21) almost a half century earlier, after analyzing students' mistakes to questions on paragraphs read silently, declared emphatically that although reading was a complex task, "it is not a small or unworthy task to learn 'what the book says.'" Today, evidence of these same conditions is a frequently recurrent theme in far too many schools. A major reason for this situation, although several theories of reading comprehension are implied in the literature, is the lack of a theory which has been clearly specified and tested experimentally. In attempts to improve these unfortunate circumstances, well-formulated theories and models are indispensable, for, whether implicitly or explicitly, educational practice is guided by some conception of the relationships among the skills.

PURPOSES OF THEORIES AND MODELS

The purpose in this paper for formulating theories and constructing corresponding models is to explicate utilitarian conceptions of the relationships among reading skills. Theories form the conceptual framework upon which these models may be built. The function of models is to help connect ideas, intuitions, or problems with the observed reality of the data. Models further suggest ways to organize and to specify the components of the questions asked. In addition, models suggest restrictions on the types of data to be tested, as well as to guide the analyzations of those data. Finally, models permit the verification, rejection, or revision of the original interpretation and become the basis for the continuous generation of additional testable hypotheses.

Thus, by the following restatement of three theories of reading comprehension, designated the independent, global, and hierarchical, and by the construction of models to represent them, a framework will be established for evaluating existing research and practice and for generating testable hypotheses.

INDEPENDENT SKILLS THEORY

The independent or isolated skills theory implies that reading comprehension is a set of different processes which may be learned independently from each other and in any sequence. Consequently, the learner is expected to perform best on that skill which he has been taught.

The independent theory is a multifactor theory which can

be represented by the model:

Fig. 1

$$X_{iA} = T_{iA} + \epsilon_{iA}$$

$$X_{iB} = T_{iB} + \epsilon_{iB}$$

$$X_{iC} = T_{iC} + \epsilon_{iC}$$

The following notations are adopted throughout this discussion:

- X represents the observed score on a test of a skill
- A,B,C represent measures of separate skills
- T represents the true score comprising the true component of a skill
- ϵ represents error variables of observed scores
- i represents an individual's score

In other words, this model says an individual's observed score on a test of a specific skill is composed of a true component of that skill plus the measurement error of an individual's score on the observed skill - therefore, each separate test of a skill is composed of only the individual's score on the true component of the skill and an error of measurement.

If a correlation matrix were constructed from this model it would ideally resemble the following:

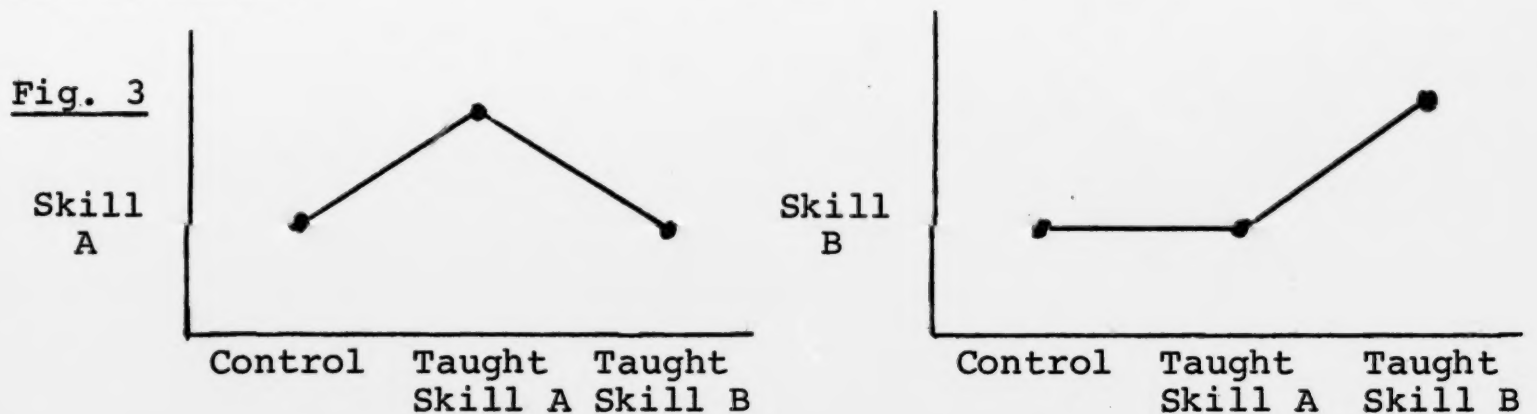
Fig. 2

TEST	A	B	C	D
A	1.00	0	0	0
B		1.00	0	0
C			1.00	0
D				1.00

Thus, if the scores of different skills were correlated, low correlations would be expected among the different skills. If the tests were factor analyzed, several factors would be expected

to emerge; and, a different factor would be found for each of the skills measured by the tests. Therefore, tests purporting to measure the same skill would have high correlations with the same factor and conversely, low correlations with factors measuring other skills.

If the model were verified by an experiment assigning two groups each to be taught two separate skills, the expected outcome can be shown:



In practice, if different groups of students were taught different skills, it would be expected that each group would do well on just the tests of the skills it was taught, and not well on the other tests, assuming the groups have equivalent levels of previous comprehension skills.

What evidence is there in support of this theory? Some authorities in the field of reading such as Gates (11), on the basis of their subjective analyses, conceptualized comprehension as consisting of various subskills which required specific kinds of instruction. Although content for each skill was specified, a sequence for learning them was not indicated. In practical teaching situations, teachers and instructional media offer corroboration that there are separate, distinct skills which must be taught.

Other researchers, such as Piekarz (19) and Letton (18), utilizing retrospective verbalizations of readers classified the verbal responses of readers into frameworks indicating that readers used various distinct skills in order to comprehend written passages.

Attempts by still other researchers to substantiate the subjective analyses of the reading process resulted in studies using statistical techniques of which the most important work were the factor analysis studies. A prototype investigation was made by Davis (8) who developed a test which he postulated contained nine separate and distinct skills. However, using factor analysis, what he identified as Component I (word knowledge) accounted for 80% of the total variance and as Component II (reasoning in reading) accounted for 9% (i.e. 90%). Thurstone (22) contended that the data did not justify interpreting even that second factor. Findings of the Davis study and those of others including Langsam (17) and Jay (15), failed to provide decisive evidence that the comprehension skills were independent.

GLOBAL SKILL THEORY

The global skill theory evolved as a consequence of the correlational results from factor analysis studies which attempted to isolate independent skills, but instead indicated that a unitary or single factor seemed to account for the given set of correlations. This theory asserts that reading comprehension is a single or unitary general process, which after being learned will enable the learner to answer any kind of comprehension question about a



given passage. Likewise, it assumes that the ability to comprehend one passage has a positive relation to comprehending another passage.

This global theory is a unifactor theory which can be represented by the model:

Fig. 4

$$X_{iA} = \beta_A G_i + \epsilon_{iA}$$

$$X_{iB} = \beta_B G_i + \epsilon_{iB}$$

$$X_{iC} = \beta_C G_i + \epsilon_{iC}$$

The same notations used for the independent model are applicable here. In addition, to compensate for the differences in measurements of skills A,B,C, β represents the weight applied to G and to each skill, G represents a standard score for the amount of the common factor in an individual score, so that βG_i represents the true global component. Thus, this model says an individual's observed score on a test of a specific skill is equal to the weight of that skill times the common factor plus the error of that skill.

From this model the following correlation matrix may be hypothesized:

Fig. 5

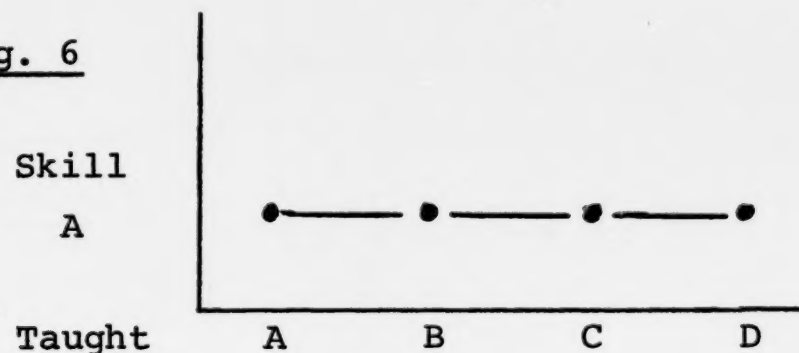
TEST	A	B	C	D
A	1.00	.90	.90	.90
B		1.00	.90	.90
C			1.00	.90
D				1.00

This would indicate that if scores on different skills were

correlated, it would be expected that high correlations exist among what appear to be single skills. If a factor analysis were performed, it would be expected that only a single factor would be extracted and all the tests would have high correlations with that factor.

In practice, acceptance of the global theory would imply that providing instruction and practice on questions developing one type of skill would teach children to respond correctly to any other type of question. For example, practice in developing vocabulary would be sufficient to teach children to respond correctly to questions about the main idea of the paragraph. Thus, the expected experimental outcome of the global theory may be represented as follows:

Fig. 6



That is, there would be no difference in the performance of the group taught skill A and the group taught skill B on a test of skill A.

Researchers, such as Thurstone (22), relied upon the correlational results of factor analysis to formulate their ideas concerning the general nature of comprehension. In 1946, Thurstone, after reviewing and re-analyzing the Davis data using a different method, concluded that the intercorrelations of the test results could only be accounted for by a single common factor. Other

studies, similar to those of Conant (7) and Harris (14), also identified a single general factor.

In an unpublished survey of fifteen textbooks on reading, this writer found only four authors who made any reference to the discrepancy between the statistical studies. The indication is that little heed is taken of the factor analysis studies as writers continue to describe independent skills in conjunction with their own subjective analyses.

HIERARCHICAL SKILLS THEORY

The hierarchical skills theory, as a result of the inconclusive research findings on comprehension skills, would seem to account for the observed phenomenon - the seeing of close relationships among the different comprehension skills yet the strong feeling that discriminably different skills exist. The hierarchical skills theory asserts that reading skills can be arranged into levels according to the complexity of the behavior necessary to learn each skill. The acquisition of knowledge using the simpler skills is a necessary but not sufficient condition for the acquisition of information using the more complex skills. This theory can be illustrated:

Fig. 7

$$X_{iA} = T_{iA} + \epsilon_{iA}$$

$$X_{iB} = \beta T_{iA} + T_{iB} + \epsilon_{iB}$$

$$X_{iC} = \beta T_{iA} + \beta T_{iB} + T_{iC} + \epsilon_{iC}$$

Also, an analysis of variance components of tests measuring skills A thru C may be developed.

Fig. 8

$$\begin{aligned}\sigma_{XA}^2 &= \sigma_{TA}^2 + \sigma_{\epsilon A}^2 \\ \sigma_{XB}^2 &= \sigma_{TA}^2 + \sigma_{TB}^2 + \sigma_{\epsilon B}^2 \\ \sigma_{XC}^2 &= \sigma_{TA}^2 + \sigma_{TB}^2 + \sigma_{TC}^2 + \sigma_{\epsilon C}^2\end{aligned}$$

Here it is seen that the observed variance of any skill is equal to the variance of a true measure of that skill plus the variance(s) of the true scores of the preceding skills plus the variance of the measurement error for the specific skill under consideration.

If this theory is accepted then it can be predicted that scores on tests measuring different skills will have fairly high correlations with each other. This relationship is explained by the following tables of fractional shared components and proportions of shared variation which assume the representations of the skills are equidistant and without error variance. Here a simplex pattern may be observed when these tests are ranked in order of complexity. Correlations next to the main diagonal will be highest because they are between pairs of tests closely related in complexity and, therefore, have a number of common components.

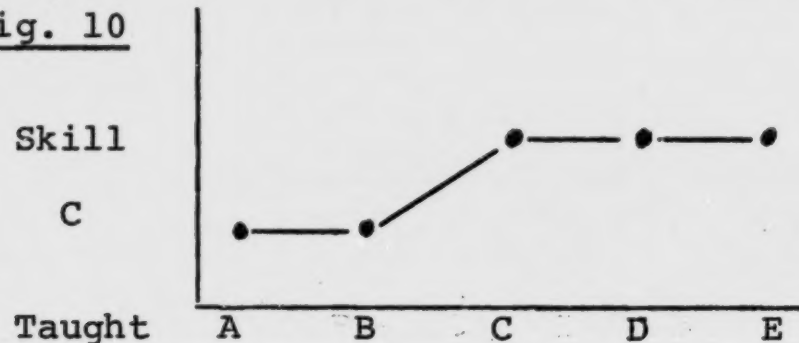
Fig. 9

Test	FRACTIONAL SHARED COMPONENTS					PROPORTION SHARED VARIATION				
	A	B	C	D	E	A	B	C	D	E
A	1/1	1/2	1/3	1/4	1/5	1.00	.50	.33	.25	.20
B		1/1	2/3	2/4	2/5		1.00	.66	.50	.40
C			1/1	3/4	3/5			1.00	.75	.60
D				1/1	4/5				1.00	.80
E					1/1					1.00

Correlations should decrease in magnitude when they are between tests that measure knowledge gained by skills differing most in complexity, because they possess fewer shared components. The simplex theory of Guttman (13) provides specific tools for analyzing the data which heretofore seemed incongruous with the empirical evidence.

In practice, children can be expected to perform best on the specific skill taught them and on the simpler skills which provide the knowledge serving as input for the more complex. While explicitly teaching one skill, a simpler skill will have been implicitly taught. These expectations are illustrated below:

Fig. 10



After re-analyzing the original 1941 Davis data and his 1967 (9) data, the intercorrelations were found to conform roughly to a simplex matrix. Bormuth (5) re-analyzed his dissertation data and found that a simplex pattern in the correlation matrix could be observed as it is in the 1941 Davis data. The major departure from the perfect simplex matrix may be due to a combination of factors, namely, (1) the reliabilities and technical qualities of the tests, and, (2) the skills tested seem, subjectively, to have formed a hierarchy more complex than the simple chain to which the simplex analysis applies. Further work is in progress to test the fit of the 1967 Davis data to the models described and to the new models described later.

A hierarchy of skills also seemed to be implied, on the basis of the writings of many reading experts, although no experimental research was found which tested this supposition. Among the first to imply this hierarchy were Gray and Leary in 1935. Recently, other authors including Bond and Tinker (4), Robinson (20), and Barrett (2) have presented conceptual models based on their conjectures that although reading skills are discussed separately they are in fact closely interrelated.

The work of Bloom (3) and Gagné (10) has led the way in considering the school curriculum as based on "learning hierarchies" in which simpler behaviorial tasks are prerequisites for learning more complex ones. Gagné's recent statement asserts that the learning hierarchy does not represent "a unique or most efficient route for any given learner" but it does represent "the most probable expectation of greatest positive transfer for an entire sample of learners concerning whom we know nothing more than the relevant skills they start with."

Further research based on experimental teaching of the skills is necessary to ascertain if this hierarchical pattern does in fact explain the actual order for learning the proposed related component skills of literal reading comprehension. As Davis (9) recently indicated "the next profitable step in the analysis of comprehension skills probably consists of applying these techniques to comprehension in the middle grades..."

EXPERIMENTAL TEST OF A MODEL

The writer, Chapman (6), has a study in progress to test the theoretical and mathematical models which propose a hierarchical

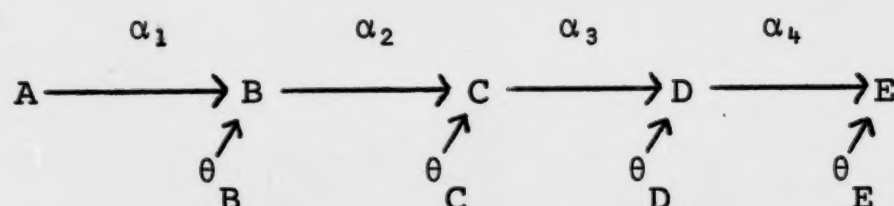


skills structure of the literal reading comprehension processes, using over 300 fifth grade urban public school children randomly assigned to one control and two treatment groups stratified by socioeconomic and ability levels. In this study reading skills are designated in terms of hierarchic linguistic units; namely, words, sentences, anaphoras, relationships between sentences, and inferences. They are postulated to be arranged in an order of simple to complex - each level serving as a building block for the next successive one. Comprehension is operationally defined as the ability to respond correctly to questions derived through wh-question transformations on the syntactic structures of verbal passages. Correct answers are defined by the same transformations. These definitions define the instructional and evaluative measures.

During the 10-week auto-instructional program, each experimental group received training designed by the investigator to develop the skills of either sentence or intersentence comprehension, while the control group received programmed arithmetic enrichment lessons. Pre- and post- tests designed for this study assessed pupils' performances relative to each other and to the control group on the experimental skills and the three others not taught.

Keesling and Wiley (16) and Wiley, Schmidt, and Keesling (23) have presented a method of analysis suitable for these data which is called "causal flow analysis." With this basic linear model, attempts can be made to test all three theories:

Fig. 11-A



This model assumes:

- A,B,C,D,E represent components of the observed skills
 α represents the causal flow coefficient connecting two skills
 θ represents an independent contribution to the observed score (residual variance not accounted for by the links)
 σ^2 represents variance of a skill

Using the above basic model, certain specific conditions can be expected for each theory. The global model implies:

Fig. 11-B

$$\sigma_A^2 \neq 0$$

$$\alpha_1 \neq \alpha_2 \neq \alpha_3 \neq \alpha_4 \neq 0$$

$$\sigma_{\theta_B}^2 = \sigma_{\theta_C}^2 = \sigma_{\theta_D}^2 = \sigma_{\theta_E}^2 = 0$$

In other words, there are no outside contributions to each skill and the global chain should not equal 0 because all components of the observed skills are related.

The independent model is represented as follows:

Fig. 11-C

$$\alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = 0$$

$$\sigma_{\theta_B}^2 \neq 0 \quad \sigma_{\theta_C}^2 \neq 0 \quad \sigma_{\theta_D}^2 \neq 0 \quad \sigma_{\theta_E}^2 \neq 0 \quad \sigma_A^2 \neq 0$$

The component skills are independent, thus the links between them are equal to 0, but there is an outside contribution to each skill.

Finally, the hierarchical model which we postulated follows:

Fig. 11-D

$$\alpha_1 \neq 0 \quad \alpha_2 \neq 0 \quad \alpha_3 \neq 0 \quad \alpha_4 \neq 0$$

$$\sigma_A^2 \neq 0 \quad \sigma_{\theta_B}^2 \neq 0 \quad \sigma_{\theta_C}^2 \neq 0 \quad \sigma_{\theta_D}^2 \neq 0 \quad \sigma_{\theta_E}^2 \neq 0$$

Here, there is a relationship between the skills, so $\alpha \neq 0$ and

there is an independent outside contribution to each skill which likewise $\neq 0$. Thus, applying maximum likelihood procedures to causal flow analysis models, it will be possible to test the goodness of fit of the hypothesized hierarchical model and of the alternative models, should this be necessary.

In summation, the review of three prevalent theories of the relationships among reading comprehension skills and the acceptance for study of the one which seemed to be most appropriate to the observed reality, should make the findings based on the Chapman data support the experimental verification, or refutation, or revision of a theory which states that the simpler skills form prerequisite knowledge for the more complex skills.

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May 2, 1969
Kansas City, Missouri